

10.  
UNITED STATES PUBLIC HEALTH SERVICE

RUPERT BLUE, SURGEON GENERAL

# MALARIA

LESSONS ON ITS CAUSE AND PREVENTION

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FOR USE IN SCHOOLS

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BY

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## INTRODUCTION.

Teaching some of the facts about malaria in schools is not new. It was done in San Antonio in 1904 after the yellow-fever outbreak of 1903, when the writer first had cognizance of it. There are chapters on malaria and mosquitoes in most of the textbooks on hygiene used in the public schools.

This paper is, however, intended to be rather more complete than the chapters devoted to malaria in the textbooks mentioned, as the importance of the disease seems to demand. Without question, in many parts of the United States where malaria is prevalent it is very important and does more injury than all other diseases combined, and measures for its control should be emphasized. As the campaign for the control of malaria is likely to be a long one, it seems very advisable so to educate the rising generation that they may bear their full part in it. Knowledge of malaria, how it is contracted, and how it may be controlled, if generally spread among all the people, will ultimately compel the control of malaria.

This paper was submitted to Surgeon von Ezdorf, Public Health Service, and has received the benefit of his suggestions, many of which have been adopted, and the writer only regrets that Dr. von Ezdorf's departure for Vera Cruz prevented his review of the entire paper.

It was also reviewed by a very successful teacher and student of pedagogy, by whose criticisms it has profited.

I wish also to acknowledge my indebtedness to Miss Ethel Neely, Secretary of the Virginia Society for the Study and Prevention of Malaria, who kindly allowed me to examine a course of excellent lessons for schools prepared by herself. The arrangement of her course of lessons—questions and answers—is followed in this paper, being better for school use than a connected narrative with the questions subjoined.

These lessons, or rather this catechism, on malaria are presented, then, for use in schools, especially those in the country, either as they are written or as a basis for lessons more suitable for the different needs of the schools in different sections.

### To the Teacher.

It was at first intended to make these lessons only for children and consequently very simple; to make them *true*, however, required either to make them less simple or to trust to the teacher to



explain difficulties, and answer questions that would naturally arise. Now it may be that some of the teachers will not have sufficient knowledge of the subject to answer the questions which will be asked and give the necessary explanation—for accurate knowledge on even the rudiments of this subject is not so common—and on that account this little paper is intended for both pupils and teachers. The questions marked (a) are intended only for the pupils. The others (b) are for the teachers and deal with ideas a little more complex than the others, yet not especially so. They contain facts, however, which a teacher must know to understand the subject at all. Some are marked (a)? as the writer was unable to decide whether they should be marked (a) or (b).

Teachers, however, will use their own discretion in giving to pupils such of the questions intended for themselves as the age and intelligence of the class may justify.

Each school should form a field class among the pupils studying malaria to find the larvæ of the different kinds of mosquitoes and to identify them and to learn to recognize the different kinds of places in which they breed; where the eggs of the different families of mosquitoes may also be found and identified.

*Culex* mosquitoes will be found in almost any standing water, especially in rain barrels, in pools and puddles almost anywhere. *Aedes* (*Stegomyia*) *calopus* will be found in artificial containers about houses. *Anopheles* will be found in the clean, shallow, shady, grassy pools described. The first two can be seen at once and recognized as not being *Anopheles* by their position, hanging head downwards. If one leans over a pool containing *Anopheles* and waits a little he will be able to see these larvæ lying flat at the surface of the water. He must wait a little, however, as they are apt to dive when one approaches them; also they frequently run to the edge and hide in the grass, so they are sometimes not so easy to see even when present. The best way to get them is with a dipper and a white saucer. *Dipping* in the water unless you see larvæ is not the best way; make a quick stroke, just skimming the water toward the edges of the pool. Carry it into the grass, because the larvæ are in the grass. Do not make this stroke until you have given the larvæ time enough after you arrived to dive and come to the top. Another way is to press the edge of the dipper suddenly under water so that the stream of water running into it may wash the larvæ into the dipper. Pour the contents of the dipper into the saucer and you will see the larvæ against the white ground. The young *Anopheles* are light grey, banded with black and very slender. The older ones are red, green, black, etc., the color depending on what they eat. They are less slender. All are quick in movement, and



though they will dive, yet they also dart along the surface of the water, which the others never do. Some are extremely small.

The eggs of *Culex* are easily recognized, being brown rafts half as large as the nail of one's little finger. (See fig. 10.) The eggs are set on end in the mass. They are common on water barrels. *Anopheles*' eggs are in loose groups (see fig. 11), the eggs lying singly on the water surface. They are very much harder to find and require a hand magnifying glass. They are usually demonstrated by keeping *Anopheles* mosquitoes in a jar with water at the bottom, the surface of which they will deposit their eggs. Eggs may also be found in nature on the surface of water containing many very young larvæ. Dip this up in a saucer and examine with a hand glass.

Keep them in a vessel with a wide mouth—fruit jar, candy jar, —half full of water or less, with pieces of grass in it extending above the water. Cover it with mosquito netting and some of them will develop into mosquitoes, and you can tell the kind. The larvæ are cannibals, and the big ones eat the others. *Anopheles* are much harder to raise than *Culex*, and unless one starts with nearly full-grown *Anopheles* larvæ or pupæ it is difficult to develop the mosquitoes from them unless one takes a pan or trough and makes enough of a marsh to imitate natural conditions. Some of the points of difference of mosquitoes and larvæ can be seen with the naked eye, but a good hand lens is of great assistance and makes the study much more attractive.

The pupils should be encouraged to do such antimalarial work as is practicable to them. That directed against mosquitoes is the most practical; compositions on subjects connected with the lessons; verbal reports—say, weekly—during the malarial season of what each one has done in the way of antimalarial work will increase the interest in this subject. The fuller the knowledge the teacher has of the subject, and the more it is explained and developed the more the pupil will be interested and will profit.





# MALARIA.

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## SECTION I.—MALARIAL FEVER AND ITS CAUSE.

Q. *What is malarial fever?*

A disease of man, common in hot, wet countries.

Q. *What is malarial fever sometimes called?*

Chills and fever, bilious fever, swamp fever.

Q. *Is this disease found in the United States?*

Yes. Along the coastal plain from Connecticut to Texas, over nearly all of the Mississippi Valley, and in a number of valleys on the Atlantic coast.

Q. *What causes malarial fever?*

The presence of certain small organisms in the blood of the man who has the fever.

Q. *What do you mean by an "organism"?*

Something that is alive and thus has the power to reproduce its kind.

It may be alive as a plant is alive, or alive as an animal is.

Q. *Is the organism which causes malarial fever a plant or an animal?*

It is an animal, and in the blood is said to be an animal parasite.

Q. *What do you mean by a "parasite"?*

An animal or plant that lives at the expense of another, like the ivy on a tree, the love vine, rust on corn, or the hookworm, flea, etc. The malarial parasite lives in man only by feeding on the blood cells of man.

Q. *How do you know that these parasites are found in the blood of those who have malarial fever?*

Because with the microscope we can see them in the red blood of a man sick with malarial fever.

Q. *What do you mean by red blood cells?*

They are very small bodies floating in the blood, shaped much like a biscuit, with thickened edges; they give the blood its red color, and are a most important part of it. They are essential to life.

### How Malarial Fever is Taken.

(a) Q. *How do these malarial parasites get into the blood?*

A. In one way only: Through the bite of a mosquito. Malaria is not acquired by eating improper food, by drinking bad water, by bathing in the sun, or in any other way than by the bite of a mosquito. True, if one already *has* malaria, that is, *has these parasites already in his blood*, doing these things will develop it—"bring out"—so that he may have a malarial attack which he could otherwise escape, but only if he is *already* infected with malaria.<sup>1</sup>

(a) Q. *Do all kinds of mosquitoes transmit malarial parasites to man?*

A. No. In the United States only *Anopheles* mosquitoes carry malaria, and only some kinds of *Anopheles*.

(a) Q. *Are mosquitoes born with this power of conveying malaria?*

A. No. They acquire it only by biting a man who has these parasites in his blood. The parasites are taken then from a man by a mosquito and go back from the mosquito to another man. Where the parasites first started we do not know.

(a) ? Q. *How, then, does malaria spread?*

A. Exactly like yellow fever. A female mosquito of a certain kind feeds on a man infected with malaria and sucks up blood with malarial parasites in it. She can not convey malaria to those whom she bites for some days (a week or more) after this, but after waiting a while (the reason for which will be told later) she injects the parasites into other men whom she bites and infects them with malarial fever.

(a) Q. *What, then, is necessary to spread malarial fever?*

A. *Anopheles* mosquitoes; malarial parasites and healthy men. The parasites may be either already in the infected mosquitoes or in infected men, from whom the mosquitoes can get them by biting.

### How to tell Malarial Mosquitoes.

(a) Q. *Do both male and female mosquitoes bite?*

A. No. The female bites. It is doubtful if the male bites. If it does bite it does so very rarely.

Q. *Can you describe the head of a mosquito?*

A. All mosquitoes have a bill and two *palpi* (*pal-pee*), which are close to it, one on each side. Outside the palpi are two *antennae* (*an-ten-nay*) which spread apart. The antennæ of the male are plumelike. Those of the female are not. (See fig. 2.)

<sup>1</sup> The teacher should here tell the class of the conveyance of malaria to Dr. Pat Manson, jr., in London, by mosquitoes infected in Italy and brought thence to London. He should also mention the results of the experiments of Sambon and Low at Ostia, living all summer in a screened house and keeping well, although drinking the same water and eating the same food, and giving them all respects except housing living like their neighbors; and give them other evidence which may be necessary to show that malaria is conveyed only by the mosquito.



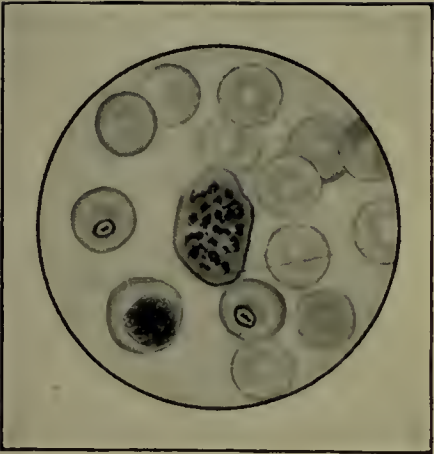


Fig. 1.—Normal red blood cells, and red blood cells containing malarial parasites.



Fig. 3.—Resting posture of mosquitoes; 1 and 2 *Anopheles*; 3 *Culex pipiens*. (After Sambon.)



Fig. 2.—Heads of mosquitoes; 1 and 2 male and female *Culex pungens*; 3 and 4 male and female *Anopheles*; 5 and 6 male and female *Aedes calopus*. (After Stitt.)



Fig. 4.—*Anopheles maculipennis* (*quadrimaculatus*), male. (After Castellani and Chalmers.)





Fig. 5.—*Anopheles maculipennis quadri-maculatus*, female. (Castellani and Chalmers, after Austen.)



Fig. 7.—*Aedes calopus*, female.



Fig. 6.—*Aedes calopus*, male.



Fig. 8.—*Culex pungens*, male. (After Howard.)

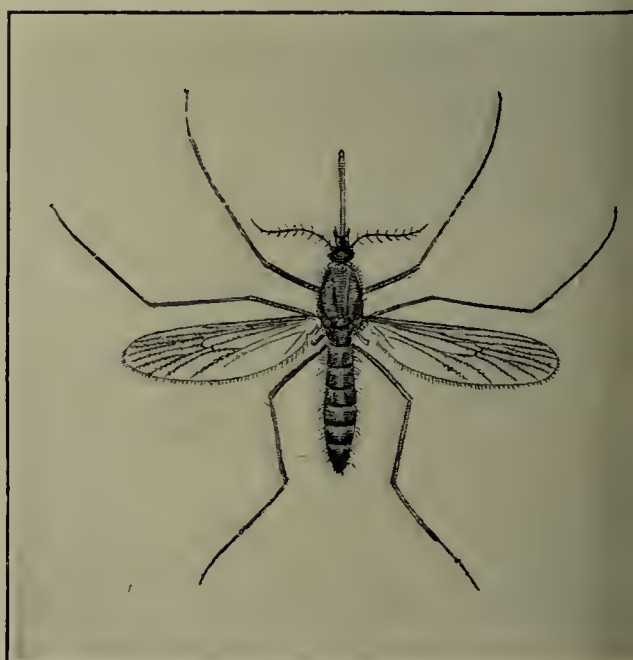


Fig. 9.—*Culex pungens*, female. (After Howard.)

Q. *How then can you tell the male from the female?*

A. The male has "plumes on his head."

Q. *How can you tell the Anopheles, malaria-bearing, mosquitoes from the Culex and other kinds in the United States which do not convey malaria?*

A. One way is by their heads. Anopheles have straight bills and palpi nearly as long as their bills. The females of the other kinds have short palpi, except one kind which has a curved bill. The males of both Culex and Anopheles have long palpi, and one can not tell the species of the males in this way.

(a) Q. *Are there any other differences?*

A. The malarial mosquito is slight and graceful. The wings are generally spotted or dusky.

(a) Q. *Is there any other difference to note?*

A. Yes. The way of resting on a wall. Anopheles rests in a straight line, frequently standing on her head. The others rest humped up." This is the only way that can be used to tell the live mosquito, and is the one usually used in practice.

(a) Q. *Can you tell something of her habits while feeding—on man, I mean?*

A. She rarely bites in the daytime in the United States. The day mosquito of the South is *Aedes* (or *Stegomyia*) *calopus*—the yellow-fever mosquito. Anopheles is shy and easily driven off, and will rarely bite one who is moving about, hence is most apt to bite one who is asleep. Her bite is less painful than that of other mosquitoes, and she does not sing so loudly. On this account, when mosquitoes are much complained of they are rarely Anopheles, and there can be many Anopheles about without much complaint.

#### Breeding of Mosquitoes.

(a) Q. *Where do these mosquitoes breed?*

A. In water—in still water and in the pools and grassy edges of running water.

(a) Q. *How do these mosquitoes breed?*

A. They lay their eggs on the surface of the water. These eggs float, and in a few days hatch into larvæ, or "wiggle-tails." These live in the water, and in time turn to pupæ, or "tumblers," which turn into mosquitoes. There are four changes in the development of mosquitoes just as for butterflies; the eggs for both; the larvæ in place of the caterpillars; the pupæ in place of the chrysalis, and the mosquitoes in place of the butterflies. For mosquitoes all these changes must take place in water, and for Anopheles will take from 2 to 16 days in summer weather—longer in cool weather.



(a) Q. *Can one tell the larvæ of Anopheles?*

A. Yes. The Anopheles larva lies at the top of the water and parallel to it, for all the world like a basking pike. The larvæ of other mosquitoes hang from the top, head downward. If the latter are touched, they will always dive. If the Anopheles larva is touched, while it may dive it will generally "scoot" along the top of the water. They are not a bit alike, and once seen no one will ever mistake one for the other.

Q. *Is it important to recognize the larvæ of Anopheles?*

A. Yes; it is far more important to recognize the larvæ of Anopheles than the mosquitoes themselves, because this enables us to find their breeding places and hence to destroy them.

(a) Q. *In what kind of places do Anopheles breed?*

A. They prefer to breed in *clean* water, in small, shallow, shady pools with grassy edges; if with grass growing in them, so much the better. A marshy piece of ground with many small pools, among bullrushes and sedge, is an ideal place. The grassy edges and quiet pools formed by obstruction on small streams are also favorite places, as are cattle tracks. They have no objection to running water unless running swiftly.

(a) Q. *Do they breed in such places only?*

A. They *occasionally* breed in almost any collection of water, unless it is very foul; shallow wells, water barrels, tin cans, etc., especially if they have leaves or grass in them or the green algæ—"frog moss." Generally, however, they avoid barrels, cans, and other artificial containers unless they have grass, moss, etc., in them.

(a) Q. *How long must a pool last to breed Anopheles?*

A. Since it takes usually about 14 days for the egg to produce the mosquito, if a collection of water dries up completely in less than 14 days, it is not apt to breed mosquitoes.

### Malarial Parasites in Man.

(a) Q. *When a mosquito injects malarial parasites into a man's blood what becomes of them?*

A. The parasites which she injects enter the red blood cells. They are then extremely small. They grow by feeding on the blood cells and get bigger and bigger. Then their edges become scalloped (see picture). Then they divide into a number of wedge-shaped pieces, meeting in the middle something like the slices of a pie. Then the blood cells break up and set the young parasites free, and each one of them starts off as a new parasite on its own account and tries to enter another red blood cell and repeat the process of its mother parasite.

(a) Q. *Into how many parts does a parasite divide?*

A. Into from 8 to as many as 24 or 32, according to the kind, so they may increase very rapidly.





Fig. 10.—A raft of *Culex* ova. (After Deaderick.)



Fig. 14.—Larva of *Anopheles* mosquito. (Castellani and Chalmers. Modified after Howard.)



Fig. 11.—Patterns assumed by *Anopheles* ova. (After Deaderick.)

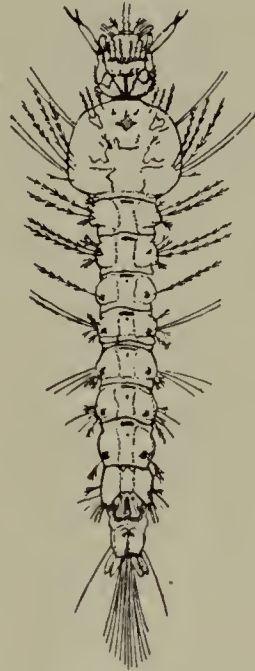


Fig. 15.—Larva of *Anopheles maculipennis* (*quadrimaculatus*). (Castellani and Chalmers, after Nuttall and Shipley.)



Fig. 12.—Egg, *Anopheles maculipennis* (*quadrimaculatus*). (After Ludlow.)

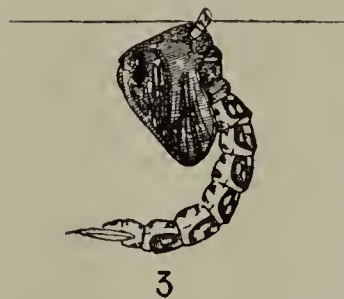
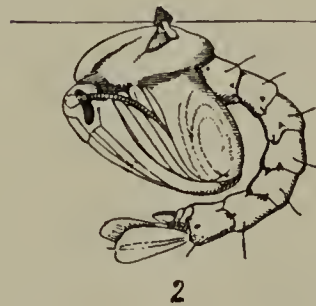
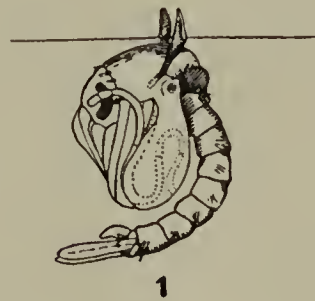


Fig. 16.—Pupae; 1 *Culex*; 2 *Anopheles*; 3 *Aedes calopus*. (After Howard.)

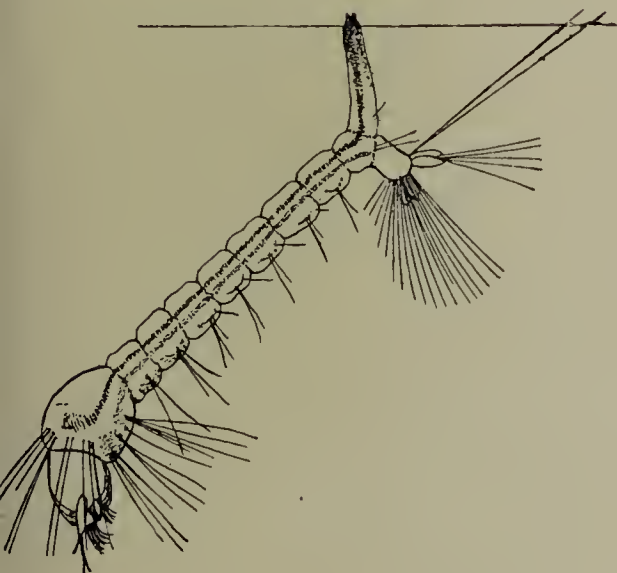


Fig. 13.—Larva of a *Culex* mosquito. (After Howard.)

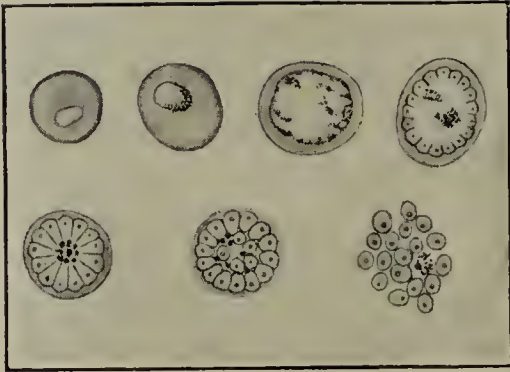


Fig. 17.—Parasites of tertian malaria.  
(After Thayer and Hewetson.)



Fig. 18.—Parasites of estivo-autumnal malaria.  
(After Thayer and Hewetson.)



Fig. 19.—Parasites of quartan malaria.  
(After Thayer and Hewetson.)

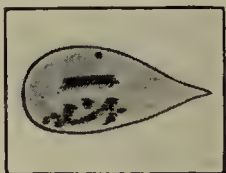


Fig. 20.—Fertilized female malarial parasite (Zygote)  
(After Craig.)



Fig. 21.—Stomach of mosquito with oocysts.  
(After Craig.)

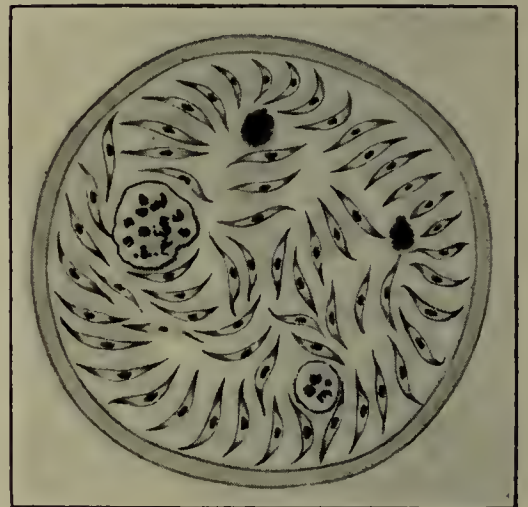


Fig. 22.—Sporozoites in oocyst.  
(After Craig.)

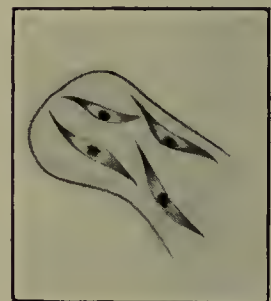


Fig. 23.—Sporozoites.  
(After Craig.)



a) Q. *Are there different kinds of parasites?*

A. Yes; there are at least three kinds, each of which produces a different form of malarial fever.

b) Q. *How long does it take from the time the parasites enter a blood cell until they divide into daughter parasites?*

A. It depends on the kind of parasite. One kind, the *tertian*, takes about 48 hours, or two days. Another, the *quartan*, 72 hours, or three days. A third, the *estivo-autumnal*, from about 24 to 48 hours. This last form is much less regular in its time than the other two; indeed, two different forms may be included under this name. It produces the worst kinds of malarial fever.

c) Q. *What causes the chill and fever of the man with malaria?*

A. When the infected red blood cells break up they liberate not only the bunch of daughter parasites, but a small amount of poison which the parasites have formed, and, when a large number of them do this at the same time, this causes the chill and fever of the sick man, which occur just after the cells break down. It has been estimated that at least 150,000,000 of parasites must divide at the same time to liberate enough poison to produce a chill—generally many times more than this.

d) Q. *Do all parasites in the red blood cells divide into others, as you have described?*

A. No. Besides the sexless forms which divide and produce chills there are two other forms of the malarial parasites in the blood cells. These are the male and female forms of the parasites. These do not seem to affect the health of the man in whose blood they exist, but it is by means of these that the mosquito becomes infected when she sucks them up.

e) Q. *How does the mosquito become infected with malarial parasites?*

A. By biting a man who has these male and female parasites in his blood. If she sucks up both kinds—male and female—she may become infected.

f) Q. *What takes place then?*

A. If the mosquito sucks up only sexless parasites with the blood she will not become infected, no matter how many she takes. If, however, the proper kind of mosquito takes up the male and female forms of the parasite they join together in her stomach and pass to her stomach wall, where they grow. After some time the bodies thus formed break and set free many young parasites, some of which finally find their way to the mouth of the mosquito. There the parasites are mixed with her saliva and are injected into a man when she bites him; then they enter the blood cells and start their life all over again.



(a)? Q. *How long does this change take?*

A. From 7 to 14 days in the summer. It takes longer in cool weather than in hot.

(a)? Q. *Is the mosquito dangerous to man until this change is completed?*

A. No. Until the parasites reach her saliva the mosquito can not inject them into the person she bites. She is not dangerous, even if she has bitten a man with malarial fever, until the time necessary for this to happen has passed.

(a) Q. *Do the parasites growing in the mosquito make her sick as they do a man in whom they grow?*

A. No. The mosquito seems to be as well as ever.

## SECTION II.—PREVENTION OF MALARIA.

a) Q. *Can malarial fever be controlled or prevented?*

. Yes.<sup>1</sup>

a) Q. *What can be done to lessen or get rid of it?*

. There are several methods which can be used.

First. By getting rid of the *Anopheles* mosquitoes which carry it.

Second. By not letting these mosquitoes get to well people to bite them.

Third. By so treating men having malarial parasites in their blood that they will not infect the mosquitoes.

Fourth. By so protecting healthy people that even if they are bitten by infected mosquitoes they will not develop malarial fever.

### First Method.—Getting Rid of *Anopheles*.

a) Q. *How do you get rid of *Anopheles*?*

. By destroying their shelters and their breeding places.

#### (1) DESTRUCTION OF SHELTERS.

a) Q. *What do you mean by their shelters?*

. *Anopheles* live almost exclusively out of doors, and as they cannot bear the hot sun they shelter themselves in the brush and high weeds all day and come out at dusk to feed.

a) Q. *What should be done to these shelters or hiding places?*

. All brush and high weeds near one's house should be cut down so that mosquitoes can not shelter themselves close to it.

a) Q. *What should be done with the brush about their breeding places?*

. This should also be cut down.

a) Q. *Why?*

First. So we can see the breeding places to destroy them.

Second. So the sun can get in and dry up some of the breeding places.

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<sup>1</sup>The control of malarial fever is a very different problem from its elimination or getting completely rid of it. The methods of work necessary to do this are simple, but to carry them out may well be beyond the economic limit allowable. To control it, however, that is to so lessen its amount that it does little injury in a community, is oftener possible. It is at last a question of economics.



Third. The less brush left to shelter mosquitoes the better, if they are exposed to the hot sun many of them die.

(2) DESTRUCTION OF BREEDING PLACES.

(a) Q. *How do you destroy their breeding places?*

A. In two ways:

(1) By draining or filling up the pools, marshes, etc., which they breed.

(2) By oiling such pools as we can not drain or fill.

(a) Q. *How does draining or filling up pools prevent breeding?*

A. By leaving no water in which they can breed.

(a) Q. *How does oiling the pools prevent breeding?*

A. It kills the larvæ.

(a) Q. *How does it kill the larvæ?*

A. The oil forms a layer on the surface of the water. Now, the larvæ must have air to breathe even if they do live in the water, and they come to the top to get it, and as they can not get through the layer of oil to get air they die. Try it on a water barrel with wiggles and see.

(b) Q. *How often should this oiling be done?*

A. Once in 12 or even 14 days would be often enough, but it is best done once a week on the same day of the week, so that it will not be forgotten. Use enough oil (coal oil or kerosene) to form a layer over the surface, so that you can see it.

(a) Q. *Can all pools be oiled advantageously?*

A. No. If there be much grass in the pool the oil will not form a layer all over it. If the pool be large, that is a pond, the wind will blow the oil over to one side so that the surface on the other side is not covered. On large pools and grassy pools oil can not be depended on.

(a) Q. *Is there any other way besides oiling in which the water in pools, ditches, etc., can be made unfit for breeding Anopheles?*

A. Almost anything that makes the water foul and bad smelling will prevent Anopheles breeding in it, such as soapsuds, dyestuffs, gas tar, refuse from mills, etc.

(a) Q. *What of water in barrels, drinking troughs, cans, etc.?*

A. Where water is often disturbed, as in chicken and horse troughs, Anopheles are not found or very rarely found; nor are they commonly found in barrels or in artificial containers of any kind, but they are sometimes, and if the water is not needed it is best to turn it out or oil it, as it may breed Anopheles, and will breed other mosquitoes, which are a nuisance even if they do not give malaria.

(a) Q. *Have Anopheles larvæ other enemies besides man?*

A. Yes. The "top minnows" that are so abundant in some of the small, sluggish streams eat large numbers of them. In places where



the minnows can get at them *Anopheles* larvæ are rarely found. Where there is grass or brush in the water frequently the fish can get to the larvæ. These "top minnows" are our most efficient allies in our fight against these mosquitoes. Big fish are of little use—indeed, do harm by eating the minnows.

### Second Method.—Preventing Access of *Anopheles* to Well People.

a) Q. *How do we prevent Anopheles mosquitoes getting to healthy people to bite them?*

(1) By screening the house; (2) by mosquito bars.

b) ? Q. *How should a house be screened against Anopheles?*

The screen should be No. 16 wire or No. 14 painted over to lessen size of the mesh. All windows should be screened and all doors, when they are left open after dusk. All holes of all kinds by which mosquitoes can enter the house should be screened or closed, including chimney. Screen doors should open outward. People should stay indoors after dusk, where mosquitoes can not reach them. *Anopheles* rarely enter a house in broad daylight. Screens with holes in them, or that do not fit tight, may do harm rather than good and mosquito traps."

c) ? Q. *How may such screens do harm?*

Because *Anopheles* mosquitoes try to *enter* a house all night long and thus have time to find the smallest opening in the screening. They try to *leave* the house at first light, and if they can not find the way out before broad daylight they are trapped in the house and hide in dark places, closets, under the bed, etc., and thus accumulate in the house.

d) Q. *How should mosquito bars be used?*

They should be of fine bobbinet, with no holes in them and *with the mesh lit up the side*. They should not go over either the head or the foot of the piece of the bedstead at night, but be tucked under the mattress all around and never allowed to hang down to the floor. They give some protection, but far less than good screening.<sup>1</sup>

### Third Method.—Preventing Infection of Mosquitoes.

a) ? Q. *How can we treat men with malarial parasites in their blood so that they will not infect mosquitoes?*

In two ways: (1) By treating everyone who has these parasites in his blood until he is *cured* completely, not just partly well, to avoid relapse later. This is the doctor's business. (2) By keeping these people in a screened house, or at least under a mosquito bar at night, as long as they have these parasites in their blood.

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How to screen houses against mosquitoes may be found in reprints of the United States Public Health Service, No. 170, Feb. 27, 1914, and No. 180, Apr. 10, 1914.



(a) ? Q. *Do people have parasites in their blood only when they have malarial fever?*

A. No. A man may have parasites in his blood and be infected by mosquitoes which bite him and yet show no signs of sickness. People are apt to have parasites in their blood for some time—days, weeks, or even months—after an attack of malarial fever.

(a) Q. *How do you explain that?*

A. (1) It takes a large number of parasites to make enough poison to produce fever, the number differing for different people, and a man may have many parasites and yet not enough to produce fever. The sexless parasites which divide are the only ones which produce fever, and there may be only a moderate number of these in the blood and yet enough male and female forms to infect mosquitoes. These last, you know, are the only forms which do infect mosquitoes.

(b) Q. *What are the people called who are well and yet are infective to mosquitoes?*

A. They are called "carriers," and spread malaria in a community just as a sick man does.<sup>1</sup>

#### Fourth Method.—Immunizing People Against Malarial Fever.

(a) Q. *How can we protect the healthy men so that even if they are bitten by infected mosquitoes they will not develop malarial fever?*

A. By the use of quinine.

(a) Q. *How is this done?*

A. If quinine is taken by anyone in small doses during the malarial season it will generally prevent him from having malarial fever.

(a) Q. *How much must be taken?*

A. Generally in the United States 4 to 5 grains every day will be enough. Where the fever is bad as much as 7½ grains may be necessary, but even 2½ or 3 grains a day will prevent a great many fevers. It is best taken after meals in one dose or in divided doses.

(a) Q. *Must the quinine be taken every day?*

A. No. It can be taken in larger doses, as 8 grains twice a week or even every five days. The first plan we think is the best.

(a) Q. *Does the quinine taken in this way injure those who take it?*

A. No. It has been taken thus by many people for a number of years, and none are known to have been injured by it.

(a) Q. *Does it make the people who take it feel badly?*

A. There are a few people whom even a very small dose of quinine makes feel badly, but generally it does not. There are very

<sup>1</sup> There seems to be a field for especially useful work on this line in the Temperate Zone among the "carriers" and people with latent malaria during the winter when there are no active Anopheles. This has not been utilized except on a small scale in the Tropics, where most of the antimalarial work has been done, and, indeed, is less applicable there. The destruction of the "seed parasites," so to speak, between malarial seasons seems very desirable.



people who can not take enough to prevent malarial fever. Sometimes when quinine makes one feel badly at first the bad feeling will disappear if he continues to take it.

(a) Q. *What is the dose for children?*

A. About one-half as much as for grown people; less for small children.

(a) Q. *What is the best preparation for children?*

A. The tannate of quinine is much less bitter than the other preparations. Made up into chocolates it is not especially disagreeable to take. It is also less apt to make grown people feel badly than other preparations.

(a) Q. *What is the dose of the tannate of quinine?*

A. About two and one-half times as much as of the ordinary dose—the sulphate.

(a) ? Q. *Do people prevented from developing the fever by these small doses of quinine ever have parasites in their blood?*

A. Yes. Unfortunately sometimes they do. To what extent this occurs and to what extent the quinine prevents the parasites from developing in the blood is not yet determined.<sup>1</sup>

(b) Q. *Are all people not protected by quinine liable to develop malarial fever when bitten by an infected mosquito?*

A. No. Some men seem to be naturally *insusceptible* to malaria. They are probably very few. In other men the having had a number of attacks of malaria produces an insusceptibility, or at least a lowered susceptibility, to the disease, and they do not under ordinary circumstances develop it. We frequently find in a malarial country families in which the children are having fever, while the older people are not. They have had many attacks in past years, and are now not susceptible to malaria. Sometimes a severe accident or a spell of sickness may render them susceptible again.

(b) Q. *Is malarial fever liable to relapse?*

A. Yes. Untreated, or imperfectly treated, it is almost sure to relapse, and to relapse several or even many times. The infection frequently lasts over from one season to another, the man being well several months between the attacks. It has been known to relapse after two years' interval. Many of the attacks of fever in a malarial country are relapses and not new infections. All those that occur in the winter and up to June or July, are probably relapses.

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Reprint No. 175, United States Public Health Service, gives a short account of the "quinine prophylaxis" of malaria.

DIAGRAM SHOWING METHOD AND MEANS OF PREVENTING MALARIA.

- I. Getting rid of Anopheles
  - (1) Destruction of shelters
    - (a) Cutting down brush and weeds.
  - (2) Destruction of breeding places
    - (a) Draining and filling.
    - (b) Oiling.
    - (c) Introducing fish.

- II. Preventing access of mosquitoes to well men.
  - (1) Screening the house.
  - (2) Mosquito bars.

- III. Preventing the infection of mosquitoes.
  - (1) Treating infected men until completely cured.
  - (2) Keeping such men under mosquito bars and in screened houses.

- IV. Immunizing people against malarial fever.
  - (1) Quinine.

PREVENTION  
OF MALARIA.